Success Factors Leading to the Sustainability of Software Process Improvement Efforts

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Abstract— **Despite the fact that many software organizations put a lot of effort into software process improvement, they still do not always succeed in sustaining the improvement results. We believe that this is due to the fact that current software process improvement frameworks and/or models do not provide any aid in form of a list of success factors that primarily contribute to the sustainability of SPI efforts. In this paper, we compile thirty two SPI success factors as elicited in theoretical and empirical studies. Our primary goal is to aid software companies in defining, planning, monitoring and improving their SPI efforts. Our secondary goal is to create a basis for identifying SPI health attributes which, in turn, would allow software companies to determine the health of their SPI projects. (Abstract)**

Keywords-SPI project health, lessons (key words)

I. INTRODUCTION

Current Software Process Improvement (SPI) process frameworks and/or models do not always provide clear evidence about the long-term health of the SPI projects and the sustainability of their results. With this we mean that successful SPI implementations do not always guarantee long lasting results [1]. Although the immediate SPI positive results may be clearly tangible, this does not imply that they will sustain in the long-run [2].

The problem of sustaining the SPI results has been widely recognized and suggestions for solving it have been made by some maturity models and development methods [3], [4]. The suggestions usually incorporate process improvement activities into software development processes. Still, however, they do not cover exhaustive list of attributes aiding software organizations in evaluating the success of their SPI projects, and thereby, aiding them in sustaining the SPI results in the long-run.

Sustainability of the SPI efforts is very important. Lack of it means that the organizations quickly go back to the old pre-SPI process state and its problems, and thereby make the SPI efforts a waste of time and resources. For this not to happen, organizations should not only implement SPI activities and check their immediate results. They should also plan, monitor and control the long-term progress of their SPI efforts and the processes undergoing SPI. For that, they need to identify the success factors aiding them in sustaining their SPI results.

Today, there are many SPI models and frameworks, development methods and experience reports dealing with SPI. They either suggest different ways of improving processes or they report on the SPI results. Many of them delineate SPI from their own perspectives, in which, they may suggest or report on the SPI success factors that are limited to and/or relevant in their own contexts. This, in turn, implies that overall knowledge of the SPI sustainability factors is provided by different authors and, thereby, scattered in many different sources. To the knowledge of the authors of this paper, however, no one has tried to gather them and put them into an overall list of SPI sustainability success factors.

In this paper, we elicit thirty two SPI success factors that primarily contribute to the sustainability of SPI efforts. We do it in two ways, via a literature study and via interviews. Our primary goal is to aid software companies in defining, planning, monitoring and improving their SPI efforts, and sustain its results. Our secondary goal is to create a basis for identifying SPI health attributes which, in turn, would allow software companies to determine the health of their SPI projects.

The remainder of this paper is organized as follows. Section II presents background of the field. Section III describes the method used during this study. Section IV lists and provides descriptions of thirty two SPI sustainability success factors. Finally, Section V presents final remarks and suggests future work.

II. BACKGROUND

There is a large amount of software maturity models that have been designed to help software organizations implement SPI activities. The best known ones are CMMI and SPICE [3], [4].

CMM Integration (CMMI) framework provides guidance for improving software organization's processes in a structured and well planned manner. It helps assess organizational maturity or process area capability, establish priorities for improvement, and implement these improvements [3]. CMMI best practices are organized into 25 process areas, which have two different representations: continuous, labeled by standardized "capability levels", and staged, labeled by tailored "maturity levels".

SPICE maturity model, also known as ISO 15504, has similar structure to CMMI. It consists of capability levels, which, in turn, consist of process attributes, and further, of generic practices. SPICE model provides tools for standardized process assessment and suggestions for defining process maturity.

Even though many software organizations are using maturity models for process improvements, there are still many organizations that are not willing to follow formal maturity models [5]. The reasons are many. Some of them are: (1) the organizations are too small, (2) process certification is too costly, (3) the organizations do not have time for it, or (4) the organizations use other SPI methods [5]. Smaller organizations are often using ad-hoc SPI methods, or, they transition from one development method to another without proper planning or preparation [6].

III. METHOD

In this section, we present our research method. We first present research steps in Section III.A. We then describe the questionnaire used in one of the steps of this study in Section III.B. Finally, we describe the validity of our results in Section III.C.

A. Research Steps

Our research consisted of the three following steps: (1) *Literature Study*, (2) *Empirical Study*, and (3) *Data Analysis*. During the first two steps, we elicited sustainability success factors, first by reviewing literature and then by interviewing software practitioners. These two steps were conducted independently. This implies that the results of the first step did not constitute input to the second step, and vice versa. In the third step, we combined and analyzed the results as achieved in the first two independently done steps. Below, we briefly describe the three steps.

1) Literature Study

During the literature study, we reviewed more than 45 publications dealing with SPI projects. These were mainly experience reports and case studies that had been retrieved from IEEE, ACM, Springer, John Wiley and Sons, and other publishers. Out of them, we chose 25 empirical reports describing conditions contributing to or subtracting from the success of SPI projects [1], [2], [7-29]. Our goal was to elicit factors that contributed to the sustainability of SPI efforts, as defined by literature.

The majority of the publications studied mainly reported on the empirical process improvement projects. They did not focus on outlining the conditions contributing to the success of SPI efforts. However, some of the conditions could be indirectly recognized out of their contexts and results. Only three publications provided direct and explicit feedback on critical SPI success factors. These were [7], [8], [9].

During the literature study, we elicited critical factors influencing SPI for both successful SPI initiation and implementation, and successful preservation of its results. This step resulted in a preliminary list of SPI sustainability success factors. Having this list as a basis, we reviewed the publications anew, now with the purpose of studying their direct and indirect descriptions, their contexts, and identifying their impact on the sustainability of the SPI efforts. This step resulted in 28 SPI success factors.

2) Empirical study

During the empirical study, we interviewed 40 software engineers who had been involved in or who had been affected by SPI projects. Among the interviewees, there were twenty two software developers, ten testers, seven development managers and one SPI manager. They came from eight different middle size software organizations, located in Vietnam (18 participants), Sweden (18 participants), Bangladesh (2 participants), China (1 participant) and Island (1 participant).

Each interviewee was interviewed only once, in a tête à tête manner. Some of the interviews were recorded, while others were not. The ones that had not been recorded were the interviewees from Vietnam. On purpose, we chose not to record them because we believed that due to cultural reasons, the interviewees might feel hampered in providing honest answers. However, the interview results were

TABLE I.   INTERVIEW QUESTIONNAIRE

1. Are you aware that the information you provide will be kept confidential?
2. Have you been involved in process improvement or process transition before? To what extent?
a. If yes, have the results of the process improvements been lasting?
i. If yes, why do you think the results have been lasting?
ii. If no, why do you think the results have not been lasting?
3. What factors contribute to the process improvement sustainability? Please list them and motivate your answers.
4. What factors prevent the process improvement sustainability? Please list them and motivate your answers.
5. What are your suggestions for keeping the process improvement results lasting/sustainable? Please list them and motivate your answers.

documented directly after each interview. The interviews lasted for forty minutes per interview in average. They had resulted in 24 SPI sustainability factors in total, out of which 20 overlapped with the factors as identified in the literature studied, and four constituted new SPI success factors that had not been identified in the literature.

3) Data analysis

During the *Data Analysis* step, we analyzed the results of the literature study, transcribed the interviews that had been recorded, and analyzed the empirical data using the hermeneutics approach. Here, we identified and analyzed the sustainability factors as elicited in both studies. Finally, we identified common and overlapping sustainability factors, combined them and created a list of SPI sustainability success factors. It is this list that constitutes the body of this paper and a basis for the future creation of the SPI health attributes.

B. Questionnaire

For this study, we used semi-structured interviews, based on a questionnaire presented in Table 1. The semi-structure implies that the interview structure was flexible, allowing new questions to be asked depending on the answers of the interviewee.

As shown in Table 1, the interviews were aimed at identifying both the success and failure factors. They consisted of the following groups of questions: (1) the reasons for why SPI efforts have been lasting, (2) the reasons for why SPI efforts have not been lasting, (3) factors contributing to the SPI sustainability, (4) factors preventing the SPI sustainability, and finally, (5) suggestions for how to keep the SPI efforts sustainable.

C. Validity

All the qualitative research methods, encounter validity threats [30]. Those threats concern construct validity, internal validity, external validity, and conclusion validity.

Construct validity refers to the degree to which inference can be made from the operational definition of a variable to the theoretical constructs [31]. The main threat to construct validity is to guarantee that the right measures have been chosen for the study. Here, the risk was that we might use wrong measures, and as a result, that we might misinterpret the SPI sustainability success factors. To minimize this threat, we conducted both theoretical and

empirical studies. Moreover, we employed the multiple sources of data during the empirical study by interviewing different roles in eight different organizations.

Internal validity refers to the degree of inferences of the cause-effect or causal relationships in the study [31]. The main thread to internal validity for the literature study was the fact that we might misinterpret the conclusions presented in the literature or use too few literature sources. Therefore, in this study, we first made a comprehensive search in various scientific sources out of which we extracted 25 experience reports. The main threat to internal validity for the empirical study was that the interviewees might have misunderstood the impacts on the SPI sustainability. To minimize this threat, we used various roles involved in SPI in different software organizations.

External validity refers to the degree of whenever the sample findings can be generalized [31]. The main external validity threat to our empirical study was the fact that the SPI sustainability factors that had been identified during the interviews were based on the experiences of only 40 individuals and eight software organizations. However, we believe that the findings and conclusions of this study can still be found useful for many other software companies planning to conduct SPI and wishing to sustain its results.

Conclusion validity refers to the degree to which the conclusions are based on the correct interpretation of the relationships of the data [31]. The conclusion validity threat to our study was that the conclusions would not be related to the data. To minimize the threat, we based our conclusions on the multiple data sources such as literature and interviews.

IV. SPI SUSTAINABILITY FACTORS

In this section, we present the SPI success factors that have been elicited both during the literature and empirical studies. All the SPI success factors identified in the literature study have direct or indirect impact on the sustainability of the SPI efforts. Therefore, when describing them, we state their relationship with the SPI sustainability wherever relevant.

During the literature study, we have identified 28 SPI success factors, out of which 20 factors overlapped with the factors that have been elicited during the empirical study. The interviews have additionally resulted in four new SPI sustainability factors.

Just because these two studies were done independently, they had led to two groups of SPI success factors: (1) the ones that are common to the two studies, and, (2) the ones that have been elicited within one type of a study but not within the other. When describing them in this section, we clearly identify their sources. Additionally, we list them and their sources in Table 2.

TABLE II.   COMPILED LIST OF SPI SUSTAINABILITY SUCCESS FACTORS

	Cluster	SPI sustainability factor	Source		Cluster	SPI sustainability factor	Source
Human factors	Education	Stakeholders are trained and mentored	Lit. & Emp.	Organizational factors (2)	Alignment	SPI is aligned with business goals	Lit.
		Stakeholders have a common understanding of the process undergoing change	Lit. & Emp.			SPI is aligned with organizational policies and strategies	Lit.
	SPI campaign	Stakeholders are encouraged to support SPI	Emp.	Implementation factors		SPI methods are tailored to specific organizational contexts and needs	Lit. & Emp
		SPI activities are accepted	Lit. & Emp.		Knowledge	Technical staff participates in SPI	Lit. & Emp.
	Commit-ment and support	Management is committed to and continuously supports the SPI process	Lit. & Emp.			Technical staff and SPI leaders possess experience and expertise in SPI	Lit. & Emp.
		Technical staff is committed to the SPI process	Lit. & Emp.			SPI method is well defined	Lit. & Emp.
	Communi-cation	Stakeholders are aware of the complexity, challenges and benefits of SPI	Lit.		Preparation and planning	Mechanisms for stabilizing the process are planned and prepared	Lit.
		Stakeholders have realistic expectations	Emp.			SPI goals and objectives are clear and realistic	Lit. & Emp.
		Information about SPI activities and its results is disseminated	Lit. & Emp.		Management	SPI leaders do not blame staff for their mistakes	Lit.
	SPI drivers	Technical staff owns the process	Lit. & Emp.			Process standards are defined and enforced	Lit. & Emp.
		External SPI leaders are trusted and respected	Lit. & Emp.				
		Internal SPI leaders are designated	Lit. & Emp.			SPI projects are effectively managed	Lit.
	Rewards	Newly introduced processes give positive results	Emp.			SPI activities are prioritized	Lit.
		Stakeholders involved are rewarded for successful SPI activities	Lit. & Emp.		Process review and measure-ment	Software process is monitored and measured	Lit. & Emp.
Organizational factors (1)	Resources	Time and resources are dedicated to SPI	Lit. & Emp.			Software process and its efficiency is continuously reviewed	Lit. & Emp.
		SPI responsibilities are clearly specified and compensated	Lit.		Continuous SPI	Mechanisms for continuous process tuning are in place	Lit. & Emp.
		People turnover is low	Emp.				

Many different roles are involved in process improvement. Their naming and responsibilities vary in different literature and industrial contexts. For this reason, we identify and define the following roles involved in SPI:

- *Stakeholder*: a person or a group that is involved in or affected by SPI.

- *Development team:* a group of developers and/or testers that work together on development of the software product.

- *Technical staff:* a group consisting of developers, testers and other roles involved in executing the process undergoing the improvement. They are the "doers", and therefore, they get affected by the process change the most.

- *External SPI leader:* a person or a group that is in charge of the overall SPI process. He/she initiates the improvement projects, requests resources, encourages local improvement efforts and establishes communication channels between different groups. External SPI leader is not the doer in the process to be improved. For this reason, he/she is seen as an external and independent role.

- *Internal SPI leader:* a person or a group within the development team who is responsible for supporting and following the SPI strategy on a local level.

To facilitate our presentation, we group the elicited SPI sustainability success factors into three categories as defined in [10]. These are *human factors*, *organizational factors* and *implementation factors*.

A. Human factors

We have identified fourteen different human SPI sustainability success factors. Human factors deal with human behavior and reactions in the SPI context.

1) Stakeholders are trained and mentored

Process improvement often implies changes to the process or introduction of new techniques and practices. Hence, as pointed out in the literature studied, the development team needs to be trained in them in order to fully understand their role in the process change. They need to be prepared for the process improvement and understand the reasons behind each suggested change. Otherwise, they would less likely follow the new process [11]. For this reason, staff training and mentoring in the new process, new techniques and practices are needed not only for implementing process changes but also for sustaining their results. In organizations or cultures where knowledge of the process is low, the training in the process is even more important [32].

The need for training and mentoring of the SPI stakeholders was also raised during the interviews. According to our interviewees, all the company employees need to have necessary training in the new method in order to be able to follow it properly and dedicatedly. Moreover, the internal SPI leaders and team members responsible for improvement activities have to be coached on how to implement improvements and how to follow the new process. According to our interviewees continuous mentoring and training increases the credibility of strategic

SPI decisions and contributes to building trust in those decisions and in the new process.

2) Stakeholders have a common understanding of the process undergoing change

The process cannot be efficiently improved unless it is properly understood. According to the literature studied, the technical staff and management have to reach consensus on the status of the current process, its problems and possible solutions, as well as the organization's vision and the improvement goals [9]. Common understanding of the current and new process, suggested changes and its potential benefits are important to increase support for process improvement among all the stakeholders involved.

Our empirical study has led to the same conclusion. According to our interviewees, technical staff should understand the reasons behind process changes, since it is mainly the technical staff, who have to change the previous habits and adapt to a new way of working. Our interviewees have also pointed out that common understanding of the new process, SPI activities and its potential benefits strongly contribute to the increase of commitment and motivation towards SPI.

3) Stakeholders are encouraged to support SPI

Commitment to and support of SPI by all the stakeholders is a great asset to help successful SPI implementation and to decrease inertia to change. Therefore, according to the interview results, all the stakeholders need to be continuously encouraged to support SPI, and to show interest in the process improvement activities.

4) SPI activities are accepted

Changes to the process may affect daily work of many employees. Therefore, according to the literature studied, it is important that all the members of the technical staff agree and accept future changes to the process [10], [23]. This can decrease inertia to change. Acceptance of process changes can be encouraged by high involvement of the technical staff in the SPI activities.

Our interviews have also led to the same success factor. According to our interviewees, if all the personnel accept the newly changed process, then there is a greater opportunity that the changed process will be sustained. Mutual acceptance of the changed process and process improvement activities is a key to sustain the results achieved by the SPI.

5) Management is committed to and continuously supports the SPI process

To provide long-term sustainable results, software improvement requires continuous investment in time, resources and effort. This, in turn, requires that management is strongly committed to and continuously supports the SPI efforts [9], [10], [12], [13], [33]. According to the literature studied, the strong management commitment helps retain high priority of the SPI projects and the continuous management support helps assure continuous supply of the required resources [9], [10], [12], [13]. It is especially important in the initial SPI phases during which the cost of SPI activities is higher than initially expected and planned [7].

Even our interviewees have stated that SPI projects need commitment and support of top management for investment in time and resources in order to achieve sustainable results.

6) Technical staff is committed to the SPI process

Acceptance of SPI activities is a critical success factor when starting SPI projects. However, according to the literature studied, it needs to be complemented with the commitment of the technical staff. Management commitment to SPI projects has already been listed as a significant success factor to SPI projects. However, commitment of technical staff is just as important [14-17], [33]. Together with the increased motivation and engagement, the commitment of the technical staff can become a driving wheel of process improvement [2]. Committed staff takes responsibility and ownership of the process and keeps process in a healthy state [2].

Commitment of the technical staff has also been elicited during our interviews. Our interviewees have stated that, if the company personnel does not commit to the process changes, it will most likely go back to the pre-SPI process state.

7) Stakeholders are aware of complexity, challenges and benefits of SPI

Since SPI requires continuous effort and often brings mainly long term results, it is important that everybody involved in it is aware of its complexity, challenges and future benefits. Hence, according to the literature studied, organizations must make sure that all the stakeholders involved are aware of them. This can be realized via education and training. Raising awareness of SPI and effective communication of its complexity, challenges and benefits strongly affects the success of the SPI projects [16-22].

8) Stakeholders have realistic expectations

Our interviews have indicated that in order to be satisfied with SPI and its results, the employees affected by SPI should have realistic expectations. Otherwise, the stakeholders would get disappointed with SPI and would not continue with it, even though SPI brought positive results.

9) Information about SPI activities and its results is disseminated

SPI projects bring many changes to the process and daily routines. These changes have to be communicated to all the stakeholders that can be directly or indirectly impacted by the changes.

According to the literature studied, insufficient communication of the SPI changes may lead to lack of transparency of the SPI projects, confused personnel and poor quality process. Team collaboration and communication, on the other hand, may help the staff members to exchange knowledge and experience during the improvement project and contribute to coherent organizational culture [9].

The need for communicating on the SPI activities and their results has also been raised by our interviews. According to them, sufficient communication positively impacts motivation in SPI and acceptance of the new process changes.

10) Technical staff owns the SPI process

Disregarding the reasons behind the SPI projects, the new process has to be accepted and followed by the team. According to the literature studied, it is important that not only external and internal SPI leaders but also all the technical staff members take on the ownership of the process to be improved. The members should take the responsibility for tailoring the process and for continuously improving it. It is only in this way they will feel more affiliated with the process and more responsible for future process improvements. This, in turn, will lead to a built-in, self-driven continuous process improvement process, which, in turn, will strongly contribute to the sustainability of the SPI results [12].

Our interviewees have also stated that the success of SPI projects is strongly related to process ownership. According to them, not only management and SPI leaders should own the process, but also all the technical staff members. They should not only be responsible for the SPI process but also for its progress.

11) External SPI leaders are trusted and respected

According to the literature studied, the level of experience, commitment and engagement of the external SPI leaders can determine the success of the SPI projects [7-10]. However, as [7], [8] claim, the authority and respect paid to the external SPI leaders is as important. Even if the SPI leaders are in a privileged position, it still does not imply that they have high enough authority, trust and respect among the technical staff members. If so, then their ideas may not be supported and successfully transmitted to the process change [7-10]. Trust and respect may only be gained via personal qualities such as honesty, credibility, reliability, experience and reputation.

Trust and respect of the external SPI leaders was also raised during the interviews. According to our interviewees, to make the SPI results last, there should be an external SPI leader, a person or a group of people who have knowledge of SPI and who take on the responsibility of driving it.

12) Internal SPI leaders are designated

According to the literature studied, the internal SPI leaders are recognized as important SPI actors since they take on immediate responsibility for leading and supporting continuous process improvement [9], [12-14]. By possessing knowledge of the process, they are able to adapt the improvement suggestions to the different needs of development teams, projects and cultures. They help SPI activities get started and their engagement aids in winning support of their team members [13].

The importance of designating internal SPI leaders was also recognized during the interviews. According to our interviewees, the involvement of the internal SPI leaders helps spread commitment to the process and create strong process ownership. Internal leadership creates continuous control that the process is followed in a correct way and that its stakeholders are engaged in SPI.

13) Newly introduced processes give positive results

As mentioned before, the results of the SPI activities should be disseminated to all the stakeholders. However, as discovered during the interviews, just the dissemination of the results of SPI is not enough. The results achieved by the early SPI effort should be positive and should speak for themself. Positive results of the newly introduced process encourages and motivates stakeholders to continue with the SPI activities and changes the opinions of those who did not support it from the very beginning.

14) Stakeholders involved are rewarded for successful SPI activities

The importance of rewards for SPI success has been mentioned in some of the studied literature sources [20].

Our interviews have also shown that in order to keep constant stakeholder commitment to and engagement in SPI, the stakeholders should celebrate the SPI success. Rewards for the improved process contribute to the increase of motivation and engagement in future SPI activities.

B. Organizational factors

We have elicited six organizational factors. Organizational factors are critical success aspects that are outside the scope of SPI. Those are related to the organizational structures and politics as well as cultural issues [10]. Still, however, they have a substantial impact on SPI sustainability.

1) Time and resources are dedicated to SPI

According to the literature studied, SPI projects need to have dedicated time and resources. As many as 72% of SPI improvement projects have suffered from lack of resources and constant time pressure [7], [11], [18], [21]. SPI projects cannot run on their own. Investment in time and people has been recognized not only for starting and implementing the SPI projects but also for sustaining the achieved results [7], [8], [10], [14], [18-20], [24].

Our interviewees were of the same opinion. According to them, process related problems often start when no one is responsible for the process.

2) SPI responsibilities are clearly specified and compensated

According to the literature studied, people involved in SPI should have clear responsibilities and compensation for their effort [7], [8]. If they are assigned to SPI related tasks, they should be relieved from other tasks. Time dedicated to the SPI activities should be compensated in the same manner as other work. Otherwise, the SPI activities will be done in a rush, they may be neglected, they may be delayed or they may even be forgotten.

3) People turnover is low

According to our interviewees, high people turnover can become a significant barrier to the sustainability of the SPI efforts. When the key employees leave the company, so does the knowledge of the process and SPI. With high people turnover, more effort needs to be spent on the education and training of the new hires.

4) SPI is aligned with business goals

The goals of SPI projects should not only go in line with the standardization of process and quality standards, but also with business goals. According to the literature studied, alignment of SPI goals with the organizational business goals contributes to the better management of, commitment to and support of the SPI projects [10], [14], [15], [25], [26].

5) SPI is aligned with organizational policies and strategies

Improvement projects often conflict with the existing organizational policies by requiring changes to routines and processes that are common to the whole organization. Therefore, as stated in the literature studied, organizational policies have to be aligned with the SPI goals and vice versa. In cases when organizations do not have any policies, they have to establish ones and make the process standardization and improvement coherent with them. Lack of organizational policies to support process changes

can potentially become a big barrier for a successful process improvement [7], [11], [14], [21].

6) SPI methods are tailored to specific organizational contexts and needs

Each organization is different with respect to its structure, culture and policies. For this reason, as stated in the literature studied, SPI initiatives should consider the contextual specifics of the organizational culture, product characteristics, customer availability and people influenced by the process. The adaptation of process improvement methods to specific organizational contexts and needs helps address individual problems and contributes to sustainable SPI efforts [9-10].

The interviews have led to the similar conclusion. According to our interviewees, if the SPI is not aligned with the organizational needs, or if it does not fit the established organizational and national culture, then it is more difficult to win people's support and commitment. Moreover, the people would resist the process changes and the results achieved by SPI would be easily lost.

C. Implementation factors

We have elicited twelve implementation factors. The implementation factors are related to the execution of the SPI projects.

1) Technical staff participates in SPI

Technical staff constitutes an important process knowledge and experience asset [9]. By knowing all the nooks and crannies of the process, they may provide useful feedback on the suggested SPI changes [23]. For this reason, it is important that they are involved in identifying process pains and in suggesting solutions for them [9], [10], [18-20], [25], [26].

The literature findings show that the involvement and participation of the technical staff reduce resistance to change, and thereby, strongly impacts the SPI success [9], [10], [14]. By being involved in the SPI activities, the technical staff members feel more motivated to adhere to the process changes, and therefore, they are more likely to accept them [9], [10]. Technical staff involvement was found especially important in immature organizations [19].

Our interviews have also led to the same conclusion. According to our interviewees, the involvement of the technical staff contributes to the alignment of SPI methods to the organizational needs. It also decreases inertia to change and increases motivation, and thereby, significantly affects the sustainability of the SPI efforts.

2) Technical staff and SPI leaders possess experience and expertise in SPI

Process improvement implies changes to the deeply ingrained organizational culture, habits, working patterns and manners that have been developed throughout a long time. To change them is very difficult. However, according to the literature studied, it is easier to change them if the stakeholders involved possess enough knowledge and experience in implementing software process improvement changes. If there is lack of such knowledge and experience, then there is a risk of using unsuitable SPI strategy and of having poor SPI execution, which could potentially fail the SPI projects [11], [12], [18-20], [34].

Few of our interviews have also mentioned the importance of knowledge in SPI by all the stakeholders involved.

3)   SPI method is well defined

Software process improvement is a complex and time consuming process. Following a well defined and structured SPI implementation method strongly contributes to its success [12], [19], [20]. According to the literature studied, the SPI method should be suitable to the organization, its size and goals.

Our interviews have also led to the same success factor, highlighting the importance of accessible and updated process documentation.

4)   Mechanisms for stabilizing the process are planned and prepared

To prevent losing the immediate advantage of process improvement efforts, it is important to stabilize the changed process. According to the literature studied, this can be done by providing a comprehensive support to those responsible for the process and by encouraging staff to practice new procedures [9]. All the roles responsible for the SPI projects should influence the process stabilization by continuously reaffirming commitment to change, communicating progress of improvements, and by providing continuous feedback and motivation [9].

5)   SPI goals and objectives are clear and realistic

SPI projects should have clearly specified goals and objectives. Our literature study shows that clear, realistic and well communicated SPI goals contribute to the good understanding of the SPI process and assurance that they are well understood across all the organizational levels [8].

Realistic SPI goals lead to realistic expectations and aid in maintaining high motivation for and support of the SPI activities. Unrealistic, too ambitious or unreachable objectives, on the other hand, may jeopardize the SPI projects, by decreasing employees' engagement and motivation even in projects with positive results [7], [14]. Our interviews have led to the similar conclusion.

6)   SPI leaders do not blame staff for their mistakes

During the SPI projects, the weaknesses and problems of the current process are continuously identified and improvements are suggested. Since the problems and negative issues of the process are continuously discussed, it is important not to start blame games [11].

According to the literature studied, blaming people for mistakes can only lead to frustration and inertia to process change [11], [24]. One should focus on process's weaknesses rather than on people's mistakes [24]. One should also encourage initiative, innovation, creativity and openness. Without it, employees cannot share valuable ideas, and thereby, contribute to process improvement [24].

7)   Process standards are defined and enforced

When the stakeholders lack dedication and commitment to the new process, people are tempted not to follow the process standards, unless there is a strong control mechanism in place [6]. Even when properly trained, the staff may not follow the newly introduced process. Therefore, as stated in the literature studied, in order to guarantee that the process is dedicatedly followed by all the stakeholders, it should be enforced and controlled by the SPI managers [6].

Our interviews have led to the similar conclusion. The interviewees have also suggested that the employees that are not following the new process procedures correctly should be informed and consequently corrected.

8)   SPI projects are effectively managed

Management of the SPI projects involves a wide range of activities such as planning for change, identifying actors involved, ensuring the level of understanding of process changes, monitoring the status of SPI, evaluating the progress, and the like. It needs to be performed in an effective and professional manner [21]. According to the literature studied, without project management, SPI projects are doomed to fail and may lead to chaos [9].

9)   SPI activities are prioritized

At the beginning of the SPI projects, companies can be overwhelmed with the amount of suggestions for the improvements. Such being a case, as stated in the literature studied, it is important not to do too many changes at ones. Instead, companies should prioritize the SPI suggestions and, focus on one or few improvements at a time [13], [14]. This leads to easier and more efficient implementation, control, measurement, and thereby, to more sustainable results.

10)   Software process is monitored and measured

Continuous process monitoring and measurement indicates whether the SPI activities are effective or not, and allows to provide early feedback on the sustainability of the SPI efforts. Hence, as stated in the literature studied, it is important to evaluate and measure the process on a continuous basis to reinsure its purpose and to increase the engagement of the SPI supporters. Measured and acknowledged process improvements will positively affect team morale and motivation [12], [13], [25], [26]. Our interviews have also stated that measurement and evaluation of the SPI results can positively impact the engagement in and motivation for future SPI.

11)   Software process and its efficiency is continuously reviewed

To achieve continuous process improvements, the SPI process and its efficiency should be reflected on and evaluated on a continuous basis. As stated in the literature studied, process reviews, such as retrospectives, allow learning from previous experience and from experimenting with the process, which, in turn, contributes to a self-driven continuous process improvement, and thereby, to the long lasting SPI results [25], [26].

Our interviews have led to the similar conclusion. According to our interviewees, process reviews help to identify problems in the current process and to acknowledge benefits achieved by SPI. This, in turn, significantly contributes to the sustainability of the achieved results.

12)   Mechanisms for continuous process tuning are in place

Software organizations have dynamic and continuously changing structures. Organizational culture, availability of the customer and background of the employees are always changing. Hence, a static process that is not improving or adapting to the changing organizational needs is failed to decay [6]. Without frequent reviews and changes to the process, it will soon outdate. Therefore, it is important to have mechanisms for continuous process tuning and improvements in place [6]. This was also concluded during our interviews.

V. FINAL REMARKS

In this paper, we have presented thirty two success factors influencing the sustainability of SPI efforts. We have elicited them in two independently conducted studies, the literature and empirical studies.

Initially, we grouped our sustainability factors into three clusters: human, organizational and implementation. When analyzing them, however, we could further group them into thirteen additional sub-clusters. As shown in Table 2, those are: (1) *Education*, (2) *SPI campaign,* (3) *Commitment and support*, (4) *Communication*, (5) *SPI drivers*, (6) *Rewards*, (7) *Resources*, (8) *Alignment*, (9) *Knowledge*, (10) *Preparation and planning*, (11) *Management*, (12) *Process review and measurement*, and (13) *Continuous process improvement.*

The SPI sustainability success factors presented in this paper constitute the body of the knowledge of the software engineering community as elicited in the current software engineering literature and in the industry. They may already be used by software development organizations when implementing and managing their SPI projects.

We strongly believe that it is not enough to just define SPI process frameworks and/or models. Process frameworks/models do not always provide clear evidence about the health of the SPI projects. For this reason, we plan to continue studying and analyzing the SPI sustainability success factors presented in this paper. Our future goal is to create a basis for supplementing currently defined SPI frameworks and/or models with a checklist of health attributes allowing software companies to define, monitor, control and improve their SPI processes, and thereby, allowing them to achieve long-term sustainable results.

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